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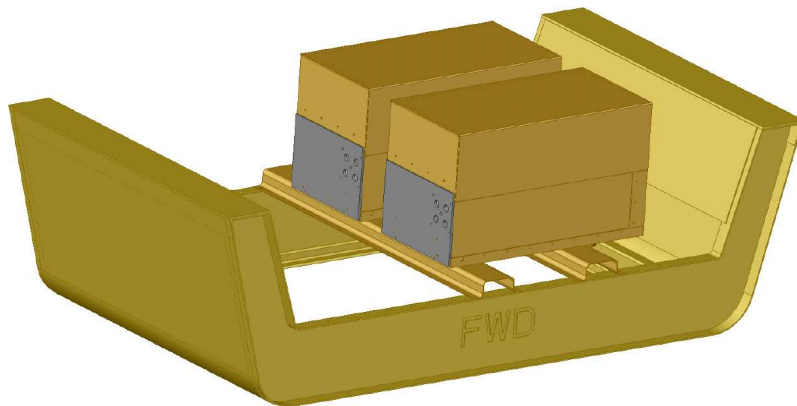
## **High Definition Sounding System Test and Integration with NASA Atmospheric Science Program Aircraft**

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## LONG-TERM GOALS

The major goal of this effort is Integration Test and Evaluation of the High Definition Sounding System (HDSS) on NASA high altitude Airborne Science Program platforms, specifically the NASA P-3 and NASA WB-57. When the HDSS is certified by NASA for reliable routine flight, the outcome will be a new capability to deploy up to 90 eXpendable Digital Dropsondes (XDDs) on demand into tropical cyclones via the WB-57.

## OBJECTIVES

Our overall objective is to enable the government to fly hurricane reconnaissance missions and automatically deploy scientific-grade dropsondes from the NASA WB-57. The ability to make up to 90 soundings simultaneously represents a major step forward in our ability to profile *in-situ* active tropical cyclones and hurricanes. Each XDD measures pressure temperature, humidity wind speed, wind direction and sea surface temperature. A second objective is demonstrating telemetry is compatible with Ku band satcom used on the various NASA platforms. A third objective is to demonstrate multiple antennae reliably acquiring telemetry during aircraft maneuvers. A fourth objective is to demonstrate the system reliability in a Global Hawk's 62000' altitude regime of thin air and very cold temperatures.

## APPROACH: Mission Profile

One or more WB-57 test flights will prove airworthiness and verify the High Definition Sounding System (HDSS) is safe and functional at high altitudes, essentially emulating flight environment of the NASA Global Hawk Unmanned Aerial System. The next goal of certification will flush out the following:

1. Confirm performance of new HDSS thermal control and insulation of five independently controlled chassis with blanket heaters and over-temperature limit cut off safety switches. Do heaters keep up with airflow?
2. Confirm air ejection effectiveness at 62000'+, measure eXpendable Digital Dropsonde (XDD) exit speeds to ensure injection outside the slipstream. Four optical detectors in exit tubes measure exit speed / acceleration.
3. Quantify survivability/reliability of sensors after ejection at 175 KIAS. Goal is 100%.
4. Verify long range telemetry bit error rates during WB-57 four minute turns using two wing mounted antennae, both with and without Ku satcom and Iridium voice active; deploy over a storm of opportunity to test telemetry reliability in heavy rain
5. Prove mechanical integrity and overall system reliability, i.e. do any internal jams occur?
6. Test sensor data against National Weather Service upper air soundings and Sea Surface Temperature (SST) vs. National Data Buoy Center buoys we overfly.

Once we are past the certification flight(s), the operational mission profile generally will follow a typical USAF 53<sup>rd</sup> hurricane surveillance cross pattern maneuver at ~62,500' to avoid cloud tops and winds. Flight plan will be dependent on storm path, designed by an experienced meteorologist (Dr. Pete Black of NRL) who will also brief the crew preflight. The actual number of flights will be a function of storms as well as ONR budgetary constraints.

## Flight Plan

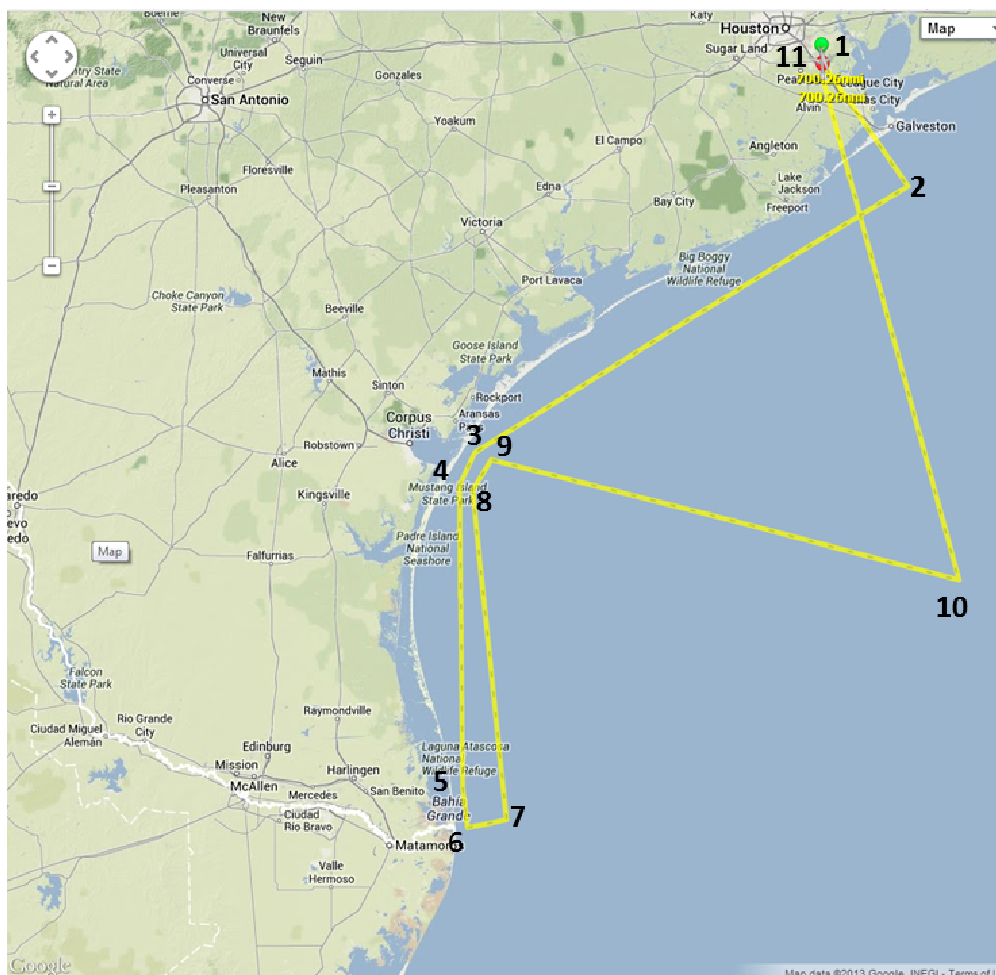
Dr. Pete Black of NRL has prepared a flight plan for initial certification flight. The layout of this plan tries to accomplish multiple objectives:

- Confirm safety of flight on the WB-57 as well as operator usability
- Test system reliability and performance in the Global Hawk operational regime
- Overfly two different coincidental NWS upper air soundings to compare PTU/Winds sensors, then overfly several NDBC buoys to test SST sensors
- Make several turns to evaluate multiple antennae reception
- Overfly a storm of opportunity to test sensors in rain

The chart and table of waypoints on the following page were created with the Flacon Flight Plan tool and assumes 400kt TAS, 150 kt IAS. Note two minute turns were assumed.

\*\* The label F=Fast, S=Slow, implies the speed of fall of the XDD sensors; R = Rain; xx:xx-total sondes: sondes in air simultaneously.

WB-57 Flight Track Waypoints follow in the table; #10 will depend on storm location.



WayPt	Location	Lat	Lon	Total Dist nm	Pt Dist nm	Time min	Total min*	Time UTC	Time UTC	Time CDT am	Time CDT pm	Sondes **
1	Home	29.521	-95.170	0	0	0	0	1100	2300	0600	1800	
2	Galveston	29.017	-94.703	42.5	42.5	6.4	6.4	1107	2307	0607	1807	1F, 1S; 2:2
3	Aransas	27.742	-97.043	187.2	147.7	22.2	30.6	1131	2331	0631	1831	1F, 1S; 4:4
4	CRP	27.596	-97.137	197.6	10.4	2.0	32.6	1133	2333	0633	1833	1F, 1S; 6:6
5	S. Padre	26.121	-97.104	285.2	87.8	13.1	46.0	1146	2346	0646	1846	2F, 2S; 10:8
6	BRO	25.987	-97.104	296.7	11.5	2.0	48.0	1148	2348	0648	1848	0, 0; 10:8
7	OffshoreB R	26.027	-96.890	308.4	11.7	2.0	52.0	1152	2352	0652	1852	0,0; 10:8
8	OffshoreC RP	27.552	-97.043	404.1	95.7	14.4	68.0	1208	0008	0708	1908	2F, 2S; 12:4
9	Offshore Aransas	27.712	-96.983	414.4	10.3	2.0	70.0	1210	0010	0710	1910	0, 0; 12:4
10	Weather	27.147	-94.434	553.673.	138.6 +120	20.8	93.0 111	1233 +18	0033 0051	0733 0751	1933 1951	4FR, 4SR ; 20:12
11	Home	29.521	-95.170	820.3		22.1	133	1313	0113	0813	2013	0,0; 20:0

## WORK COMPLETED

Under this work we have conducted the first pressurized test flights on the NASA P-3, passing the ground pressure check. In June 2013 aboard the NASA DC-8 aircraft we demonstrated long range telemetry of more than 150 miles over the northeastern Pacific. We have submitted a Payload Design Package to NASA Johnson Space Center's WB-57 team, and we plan on test flying in September as described below.

### HDSS Payload Description

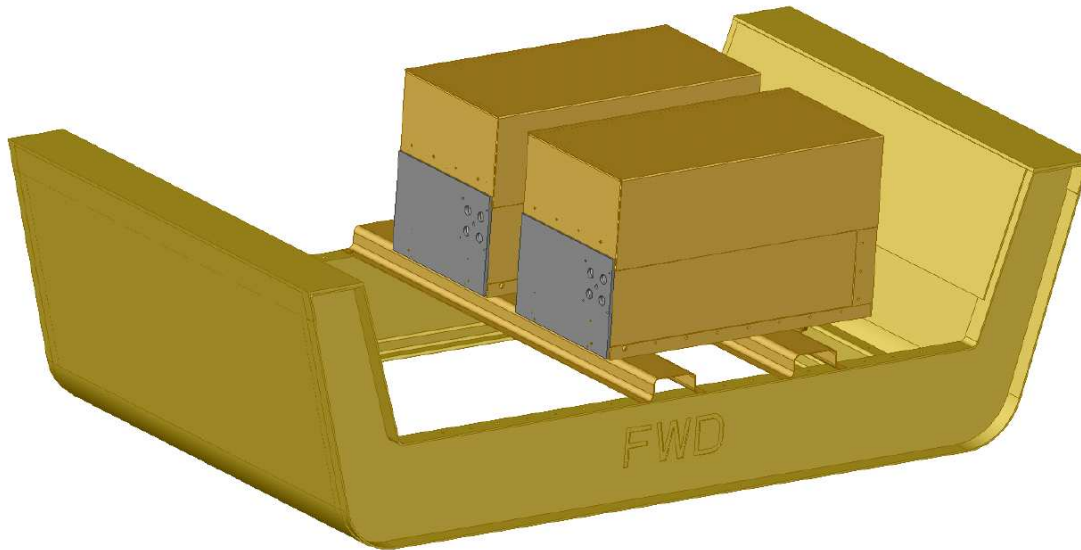
As seen in Figure 1, the HDSS deploys expendable XDD sensors via dual fully redundant Automated Dropsonde Dispenser (ADD) units, which each contain both an embedded controller with network interface, GPS and a multi channel telemetry receiver. ADDs can be used alone or together as they do not share spectrum – one covers 400-403 MHz while the other 403-406 MHz and the tubes are mechanically “deconflicted”. Each ADD can be loaded with up to 12 XDDs (24 per HDSS). If magazine extender boxes are fitted, up to 48 can be loaded (a total of 96 per HDSS). Much like other aircraft systems, the HDSS provides reliability through complete hardware redundancy.

The initial goal is to get the HDSS flight qualified on the WB-57 with 24 XDD devices to simulate the flight environment of the Global Hawk, test wing mounted telemetry reception during aircraft maneuvers and ensure compatibility with Ku satcom. Prior to each flight expendables are loaded via the lower access doors, or by lowering the pallet itself to gain access to the magazine door. After the HDSS is qualified we'll overfly a “hurricane of opportunity” for in-situ reconnaissance. Science goals are to enhance track and intensity prediction forecast model accuracy. Note that dual ADD hold 12 XDDs providing redundancy; for future missions blank magazine extenders may be fitted to accommodate loading up to 96 devices per flight.

Two 16” long by 3” diameter PVC drop tubes will protrude at a slight canted angle from the bottom of the pallet – these are the only two required penetrations of the pallet. 110 Vac controlled heaters regulate payload temperatures above the local dew point.

Dr. Pete Black, NRL meteorologist and NASA HS-3 scientist, will deploy multiple XDD sensors via the WB-57's Ku Satcom into a storm well below the flight level to test Technical Readiness Level as well as validate the scientific quality of sensor results.

Note while the HDSS is fully self-contained and remote controlled, if satellite communications are lost manual XDD release by the SEO cockpit operator is done via three switches for each ADD. One switch places the ADD in manual mode, which doubles as a drop-inhibit safety. The other two drop a device from one of two lanes, enabling slow or fast devices.



**Figure 1. 3D view of HDSS payload mounted in pallet. Drop tubes protrude beneath the pallet from each of two Automated Dropsonde Dispenser units, shown fitted without blank magazine extensions. Note use of aluminum cross bars; no loads are placed on exterior. Without magazine extenders this configuration supports a load of 24 XDDs.**

- Overall HDSS weight is ~200 lbs. not including the pallet
- HDSS center of gravity (CG) location approximately the center of the pallet
- Dimensional layout of the HDSS fits laterally within the 3' x 5' unpressurized WB-57 pallet, extending approximately 15" above the pallet's sides
- No laser, fluid, chemical, RF transmission, pressure/vacuum systems and no special handling requirements or specific hazards are present.
- XDDs weigh 58g and are ejected by air at between 8-12 meters/second in flight.

## XDD Description

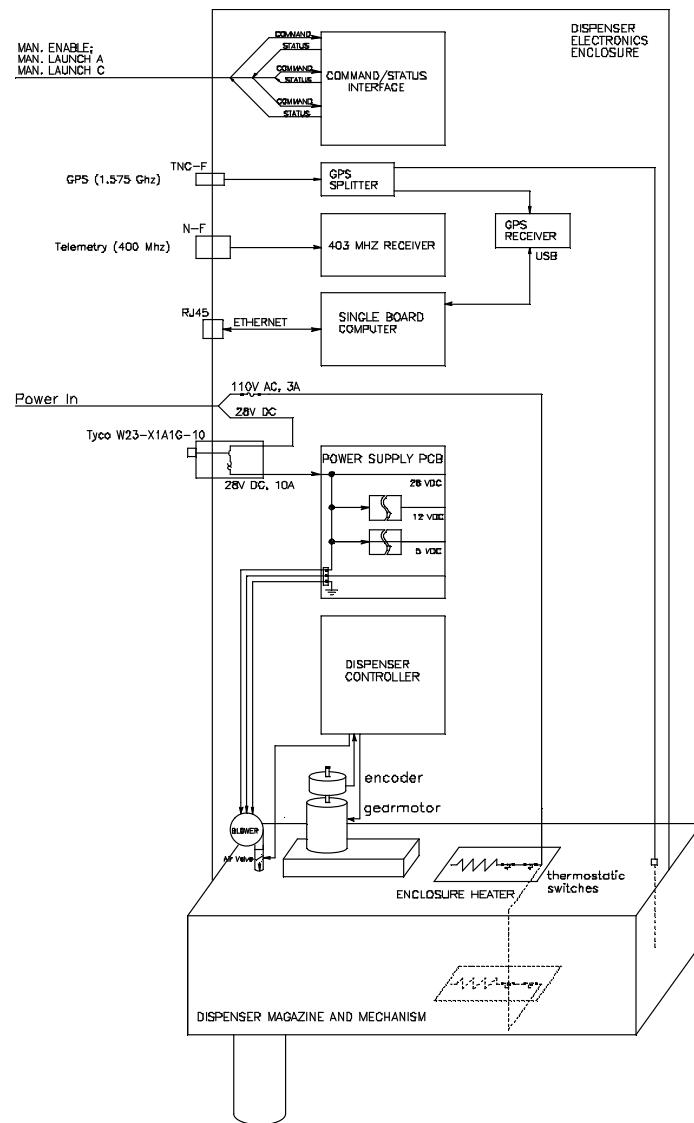
The eXpendable Digital Dropsondes (XDD) weigh 58g and are 2.6" in diameter and 7" long. The battery-powered disposable precision meteorological sensors telemeter real time sounding data to the HDSS receivers. Once a second, via reliable digital error correction techniques, air temperature, pressure, relative

humidity, horizontal wind speed, wind direction, and sea surface temperature are sent within the 400-406 MHz federal meteorological band that is reserved for radiosondes. From these soundings, important meteorological parameters can be calculated, typically presented via a “Skew-T” plot.

### ***Electrical Loads***

HDSS payload heaters are fed by off one of three phases of 110 Vac 400 Hz; each is a single phase and has a temperature control and an over temperature cutoff. All primary electrical loads are separately fused and consist of zones of chassis heaters (max 100 watts / 0.11amps each @ 110Vac) plus dual 28 Vdc @10A each “electronics” loads for left/right or fore/aft ADD dispensers, plus a separate 28 Vdc feed. With the exception of a cooling fan/blower that is directly connected to 28 Vdc loads are driven by a custom DC-DC converter board via 12 Vdc and 5 Vdc, successfully tested on the Navy Twin Otter, the NASA P-3 and DC-8. When the aircraft is powered on the system initiates is ready to communicate within a minute; heaters warm up to the set point with maximum current draw on 110Vac at warm up time. Generally, the colder the flight level, the more heat will be required to maintain the set point. All heaters are fuse protected and dedicated over-temperature mechanical cut off limit switches are wired in series if the thermostat fails shorted (i.e. full ON).





**Figure 2. Block diagram of ADD, which includes an Airhub 400 MHz Met Data Receiver.**

01/14/13 LADBS 2012/13-10

1. Drawing date changed to Aug 2, 2013.
2. Cable length 10 feet.
2. EIP-11": Left Dispenser, left Receiver  
EIP-12": Right Dispenser, right Receiver  
SOAP experiment.

1. Drawing date changed to Aug 2, 2013.
2. Cable length 10 feet.
2. EIP-11": Left Dispenser, left Receiver  
EIP-12": Right Dispenser, right Receiver  
SOAP experiment.

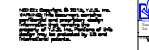
3. J1: ON = manual launch  
J2: ON = launch from lane A  
J3: ON = launch from lane C

4. Power to GPS antenna provided from Dispensers (splitter selects source).

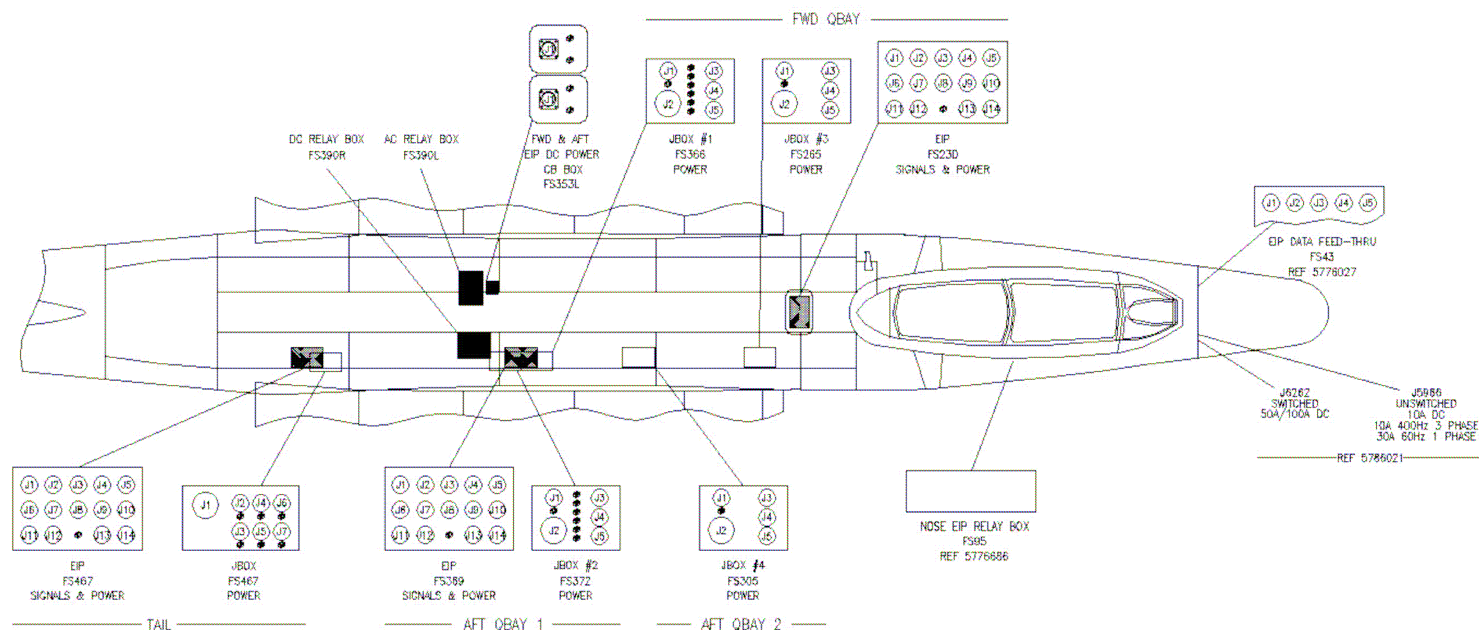
5. Plugs: P6-EIP1,  
P7-EIP1,  
P6-EIP2,  
P7-EIP2 and  
P8-EIP2  
are Military P/N: MS3476W20-16P

6. Plugs: P1-EIP1,  
P2-EIP1,  
P3-EIP1,  
P1-EIP2,  
P2-EIP1,  
P3-EIP2 and  
P4-EIP2  
are Military P/N: MS3476W22-55P

\* Indicates Amphenol-Connex Part Number  
 \*\* Indicates Conec Part number

Page"; *Yankee Environmental Systems Inc, ONR Contract N00014-12-C-0623*

# NASA WB-57 Payload EIP Layout



EXPERIMENT INTERFACE PANEL (EIP)
INTERNAL WIRING - EIP2110
SIGNAL & INTERLOCK - 5775082
J1 - J5
EXPERIMENT CONTROL & FAIL LAMP
A22 DATA - NAV, HDG, ALT
ROLL & PITCH SINCRO
IRIG B, WOV SWITCH
POWER DISTRIBUTION - 5786021
J8 - J10
2 EA 115 VAC, 400 Hz, 3 PHASE @ 15A
2 EA 28 VDC @ 35A
J11 - J12
2 EA 28 VDC @ 35A
J15 - 28 VDC, 35A INPUT
J18 - 115 VAC, 400 Hz, 3 PHASE 15A INPUT
SIGNAL FEED-THRU - EIP2110 (NOT USED)
J15 - J14 SIGNAL OUTPUT
J17 SIGNAL INPUT

TAIL J BOX
INTERNAL WIRING (TAIL) - 41-98860-048
POWER DISTRIBUTION - 5786021
J1 - 28 VDC (1) @ 50A (1) @ 100A
J2 - 28 VDC @ 15A
J3 - 28 VDC @ 15A
J4 - 115 VAC, 60 Hz, 1 PHASE @ 15A
J5 - 115 VAC, 60 Hz, 1 PHASE @ 15A
J6 - 115 VAC, 400 Hz, 3 PHASE @ 15A
J7 - 115 VAC, 400 Hz, 3 PHASE @ 15A

QBAY #1 & #2 J BOX
INTERNAL WIRING - 41-98860-018
POWER DISTRIBUTION - 5786021
J1 - 115 VAC, 60 Hz, 1 PHASE @ 30A
J2 - 28 VDC (1) @ 50A (2) @ 100A
J3 - 115 VAC, 60 Hz, 1 PHASE @ 10A
J4 - 115 VAC, 400 Hz, 3 PHASE @ 35A
J5 - 115 VAC, 60 Hz, 1 PHASE @ 15A

QBAY #3 & #4 J BOX
INTERNAL WIRING - 41-98860-018
POWER DISTRIBUTION - 5786021
J1 - 115 VAC, 60 Hz, 1 PHASE @ 30A
J2 - 28 VDC (1) @ 50A (1) @ 100A
J3 - 115 VAC, 60 Hz, 1 PHASE @ 10A
J4 - (2) 115 VAC, 400 Hz, 3 PHASE @ 15A
J5 - 115 VAC, 60 Hz, 1 PHASE @ 15A

RIGHT & LEFT WING DSM/PMS I/O BOX
INTERNAL WIRING - 41-98860-024
J1 - DIGITAL/PMS I/O PORT #1
J2 - ANALOG INPUTS 0-7
J3 - ANALOG INPUTS 8-15
J4 - DIGITAL/PMS I/O PORT #2
J5 - DIGITAL/PMS I/O PORT #3
J6 - DIGITAL/PMS I/O PORT #4
J7 - SERIAL PORT #1
J8 - SERIAL PORT #2

RIGHT & LEFT WING J BOX
INTERNAL WIRING - 41-98860-021
POWER DISTRIBUTION - 5786021
J1 - 28 VDC (1) @ 50A (1) @ 100A
J2 - 28 VDC @ 15A
J3 - 28 VDC @ 15A
J4 - 115 VAC, 60 Hz, 1 PHASE @ 15A
J5 - 115 VAC, 60 Hz, 1 PHASE @ 15A
J6 - 115 VAC, 400 Hz, 3 PHASE @ 15A
J7 - 115 VAC, 400 Hz, 3 PHASE @ 15A
J8 - 28 VDC @ 15A
J9 - 28 VDC @ 15A
J10 - 28 VDC @ 15A
J11 - 115 VAC, 60 Hz, 1 PHASE @ 10A

EIP DC POWER CB BOX
INTERNAL WIRING - 5776206
POWER DISTRIBUTION - 5786021
J1 - 2 EA 28 VDC @ 35A

AC POWER RELAY BOX
INTERNAL WIRING - 5786022
POWER DISTRIBUTION - 5786021
J1 - 115 VAC, 400 Hz, 3 PHASE INPUT
J2 - CONTROL INPUT
J3-J9 - AC OUTPUT TO J BOXES

DC POWER RELAY BOX
INTERNAL WIRING - 5786023
POWER DISTRIBUTION - 5786021
J1 - 28 VDC INPUT @ 50A
J2 - 28 VDC INPUT @ 100A
J3 - CONTROL INPUT
J4-J10 - DC OUTPUT TO J BOXES

NASA 926 ONLY

LAYOUT SCHEMATIC,  
AIRCRAFT PAYLOAD INTERFACE

## **Antennas**

There are a total of six antennas in the HDSS payload and all antennae are receiving-only. Two wing-mounted 400 MHz blade antennae have a base mounted low noise amp (LNA) that is DC phantom powered by the receivers within HDSS pallet via the center conductor of the SFT-393 coax. (To protect the LNAs from static damage, Q-bay ends are capped when not in service.)

The HDSS pallet has two nadir-mounted antennae including a third 400 MHz telemetry blade antenna. On top of the WB-57 there are two additional zenith-mounted GPS/2.4 GHz antennae that need microwave coax to reach. NASA is allowing us to use one zenith-mounted GPS L1/L2 antenna and we will provide the second 2.4 GHz antenna. Two wing-station-mounted 400 MHz blade antennae are at JSC for attachment to the WB-57. While there is no transmission of RF from any antenna we request NASA use braided straps to minimize ground impedance of the wing-mounted antennae. We understand that although we would prefer to be at the wingtips that the spoiler actuators within the wings have forced us to be mounted 20' from the end. The geometry of that more inboard location limits our maximum permitted bank angle, yet still allows us to test reliability of multiple antennae receiver concepts.

## **Pressure Systems**

The WB-57's 5 PSI air line assists pneumatic exit at high altitudes and an exit speed sensor measures each drop's velocity and acceleration; we anticipate an altitude-dependent XDD exit speed of between 8-12 meters per second. Note that the magazine acts as a small air tank, however, depending on testing that cannot be performed until the system is deployed at altitude a 7.5 gallon air tank in series with the 5 PSI air supply line provides reserve air. (This "dump tank" was used on our successful Navy CIRPAS Twin Otter test, yet the later pressurized tests on the NASA P-3 rendered it unnecessary.)

## **Hazard Analysis**

We have identified hazards and explained control that exists to eliminate or mitigate the risk involved.

- a. Flammable/combustible material, fluid (liquid, vapor, or gas) – *PVC exit tubes, foil-covered polyiso foam insulation around ADDs – mitigation: see next section*
- b. Toxic/corrosive/hot/cold material, fluid (liquid, vapor, or gas) – *not applicable*
- c. High pressure system (static or dynamic) – *WB-57 aircraft 5 PSI max air line*
- d. Evacuated container (implosion) – *not applicable*
- e. Frangible material – *XDDs are 58g and frangible; drop tubes are plastic*
- f. Stress corrosion susceptible material – *PVC outside, aluminum inside*
- g. Inadequate structural design (e.g., low safety margin) – *confirmed via structural analysis*
- h. High intensity light source including laser (e.g., unintended reflections) – *not applicable*
- i. Ionizing/electromagnetic radiation – *not applicable, "no nuclear components"*
- j. Rotating device – *rotating drum is under CPU control, stops with 28 Vdc power off*
- k. Extendible/deployable/articulating experiment element (collision) – *18" plastic drop tubes*
- l. Stowage restraint failure – *XDDs are constrained inside Al magazines*
- m. Stored energy device (e.g., mechanical spring under compression) – *not applicable*
- n. Vacuum vent failure (e.g., loss of pressure/atmosphere) – *not applicable*
- o. Heat transfer (habitable area over-temperature) – *heater overtemp shut offs*
- p. Over-temperature explosive rupture (including electrical battery) – *not applicable*
- q. High/Low touch temperature – *insulated*

- r. Hardware cooling/heating loss (e.g., loss of thermal control) – *system should still function*
- s. Pyrotechnic/explosive device – *not applicable*
- t. Propulsion system (pressurized gas or liquid/solid propellant) – *uses 5 PSI air*
- u. High acoustic noise level – *not applicable*
- v. Toxic off-gassing material – *not applicable*
- w. Mercury/mercury compound – *not applicable*
- x. Organic/microbiological (pathogenic) contamination source – *not applicable*
- y. Sharp corner/edge/protrusion/protuberance – *not applicable*
- z. Flammable/combustible material, fluid ignition source (e.g., short circuit under-sized wiring/fuse/circuit breaker) – *PIR insulation is foil-clad*
- aa. High voltage (electrical shock) – *all external wiring is Teflon*
- bb. High static electrical discharge producer – *low voltage*
- cc. Software error or computer fault – *dual redundant CPUs, can be powered off*
- dd. Carcinogenic material – *not applicable*
- ee. Rapid depressurization of aircraft (e.g., optical window fracture) – *not affected*
- ff. Uninterrupted power supplies – *none*
- gg. Transfer of liquid or gas in flight – *none*
- hh. Liquid or gas leak (e.g., improper containment, electrical short circuit) – *none*
- ii. Other

There are no liquid chemicals, however, to thermally insulate the five chassis on the HDSS we are using foil aluminum-clad Polyisocyanurate (PIR) foam insulation to surround the chassis. Although widely used in the construction industry the foam itself presents a mild fire risk. NASA has deemed this to be an acceptable risk if we foil tape all seams to cover/encapsulate the foam. The PIR foam helps maintain the HDSS chassis at an elevated near-room temperature and is surrounded by an aluminum clad wall with a 1.5 mil thickness. If cut, PIR itself can be a mechanical irritant to skin, eyes, and upper respiratory system during fabrication (such as dust), however, no statistically significant increased risks of respiratory diseases have been found in studies. The main safety issue on our aircraft application is that PIR is somewhat flammable, however, the 1.5 mil aluminum-clad will not leave any exposed foam.

There are many brands sold in the construction industry; a Material Safety Data Sheet for Atlas Roofing Corp's PIR is located here: <http://www.atlasroofing.com/download.php?uid=52>

### **Ground Support Requirements**

At NASA JSC we'll need a 5 PSI shop air line with the same quick disconnect fitting as the WB-57, as well as 110 VAC ground power and 28 VDC power to simulate an EIP, which is available in the WB-57 lab area. We also need a small amount of air conditioned (cool dry) space to store the XDD sensors prior to loading them into the HDSS.

We will need to connect our PC to the Ku satcom provider's Cisco router; we plan to bridge this PC via WiFi to the NASA LAN, and require guest access to the NASA network for the PI. There are two reasons for this: to enable the HDSS to forward aircraft GPS position data to NASA Ames' Mission Tool Suite server, and to enable other NASA/DoD scientists to control the HDSS and monitor XDD sounding data in real time as the NASA WB-57 is in flight.

### **Support for NASA Mission Tools Suite**

NASA is providing us with six static Ethernet addresses on the WB-57 and at least one address for the

PC in the JSC WB-57 hangar. During initial and subsequent flight tests, in order to execute drops in dynamic storms, remote users will need to be able to observe the HDSS' position on the Mission Tools Suite (MTS), which NASA's Airborne Science Program uses. To support real time updates of the WB-57's position, the HDSS will periodically relay its GPS position to NASA Ames Research Center's MTS server via Ku satcom.

Because the WB-57 Ku satcom is essentially a 'data island' existing on a Virtual Private Network (VPN), in order to provide TCP/IP network access and transfer live data onto the NASA network it's necessary to provide a TCP/IP *network bridge*. We plan to use a Windows XP laptop in the NASA JSC hangar connected via 802.3 100 Base-T RJ-45 directly to the Ku satcom's Cisco router on a static TCP/IP address. This laptop PC will then use a separate WiFi network interface to connect to NASA's LAN. This will create a bridge that will allow us to relay the data from the VPN to the Internet. A software program will run to relay the position data to the MTS server located at NASA Ames.

### **HDSS Stress Analysis**

Extensive stress analysis has been performed on the ADDs which are the primary pressure vessels, and that analysis is supplied as a separate PDF. The design philosophy of the HDSS mount is for the five mechanical chassis to be mechanically attached via multiple horizontal 2x4" extruded aluminum extruded box stock, which are secured to the side rails with AN type hardware. Except for the drop tubes and blade antenna, mechanical loads are not applied to the external skin of the pallet.

Ultimate load factors are taken from Section 7.2.1.1 of the *WB-57 Experimenter's Handbook*

- Forward: 3.0 g's
- Aft: 1.5 g's
- Down: 3.0 g's
- Lateral: 6.1 g's
- Forward: 1.5 g's

Various masses in the HDSS pallet and their locations are given in Table 1.

**Table 1**

ITEM	Distance Forward from Aft Edge [inches]	MASS [pounds]
ADD 1	6	70
ADD 2	18	70
AIRHUB 1	28.5	15
AIRHUB 2	28.5	15
SOAP	28.5	15

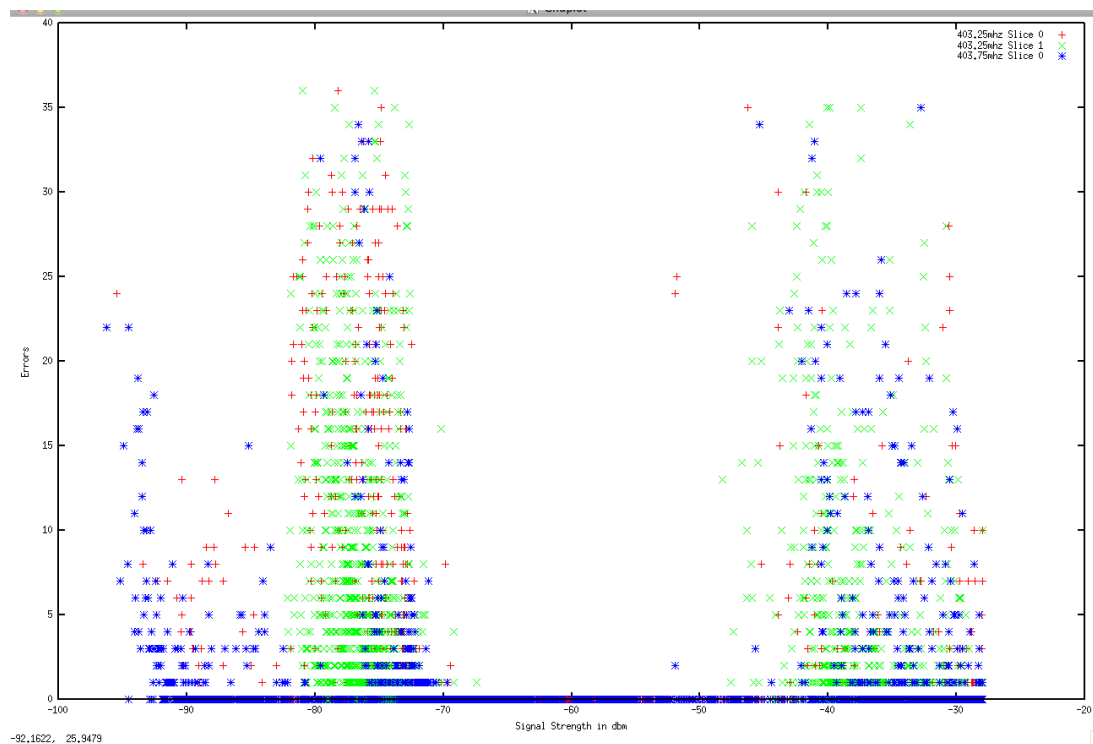
### **Pneumatic XDD Ejection Tubes**

We've reviewed the Rake Data report by Ru-shan Gao of NOAA's Aeronomy Lab, dated Feb. 5, 2002. Based on that information, along with ground clearance data we are designing a 16" long by 3" diameter drop tubes that will be canted slightly at between 10-20 degrees of vertical. The design of the tube is similar to tubes we have used on the Navy CIRPAS Twin Otter, the NASA P-3 and the Lockheed-

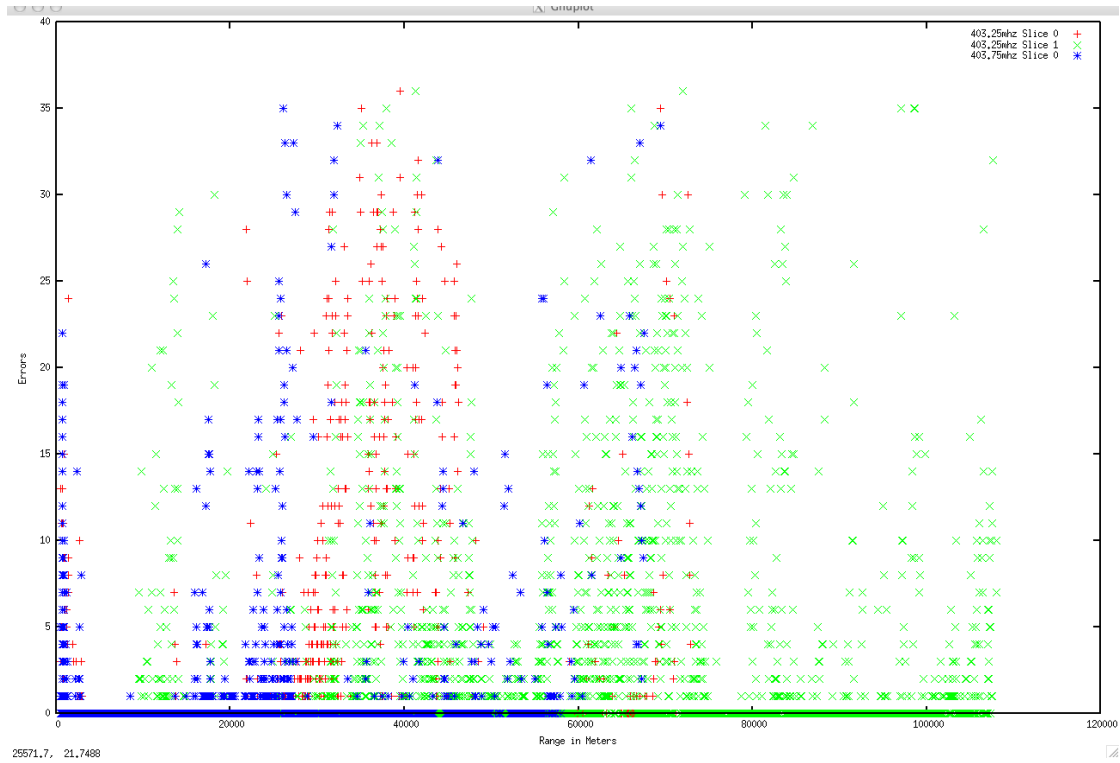
designed NASA DC-8. Based on this past experience we believe this design will ensure XDDs will clear the fuselage outside of the WB-57 slip stream. The WB-57's 5 PSI line will be connected to a precision low pressure regulator attached to the inlet of the ADD's air blower. The air blower output will slightly pressurize the magazines to about 1 PSI (at sea level). Quad optical detectors in the ADD exit tubes enable the HDSS to measure both the speed and acceleration of each XDD drop. Users can manually set the master air control valve to modify air flow via the HDSS web control interface; this will allow us to experiment with valve settings at various altitudes to explore altitude-dependent exit speeds.

## RESULTS

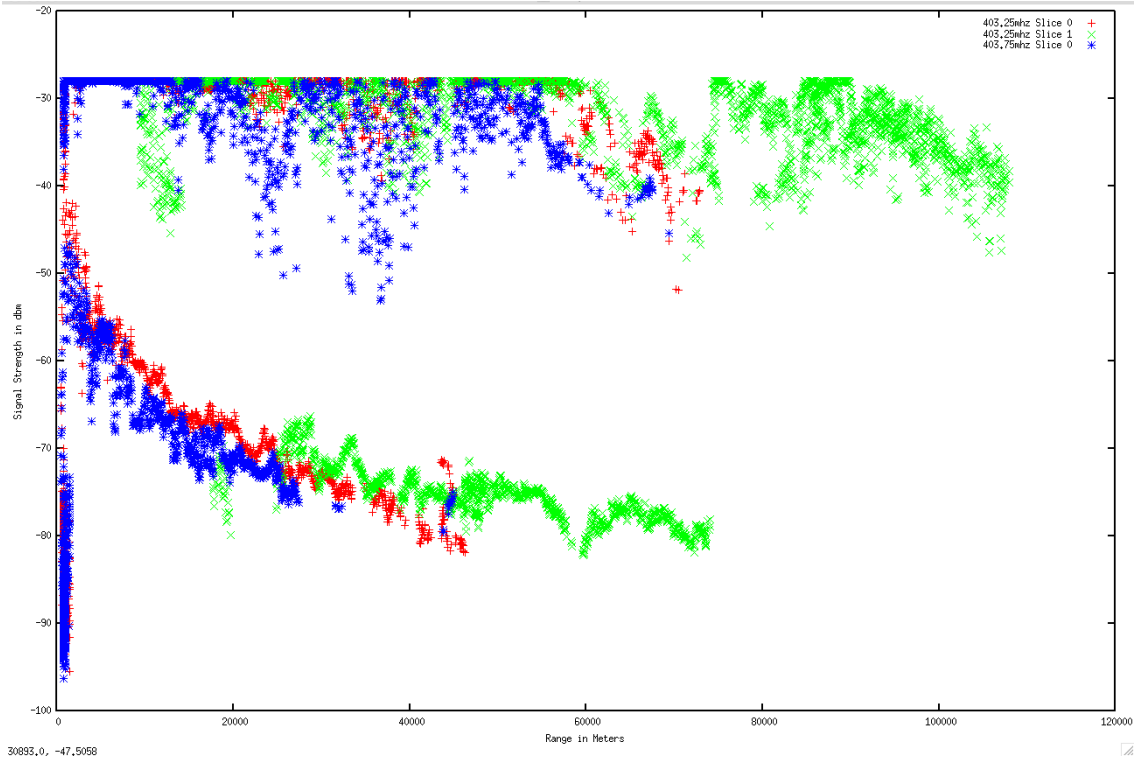
We conducted the first pressurized test flights on the NASA P-3 in October, 2012, which required successfully passing a 7 PSI ground pressure check. Significant engineering was required on the ADD to enable this initial flight, but unfortunately the NASA piggy back mission we attached to ended prematurely, and the P-3 went into a major renovation. We moved to using the DC-8 and in June demonstrated long range telemetry of more than 150 miles over the northeastern Pacific. The DC-8 was travelling at 42000' at about 500 Kts true and seven out of eight XDDs survived ejection and reported data to the sea surface. The DC-8 test also verified that our pressure noise problem previously observed on the Twin Otter tests are solved, and that we have adequate descent rates.



**Figure 5. Signal Strength in db vs Bit Error Rate. Note bimodal distribution, an artifact of the receiver Automated Gain Control subsystem.**



**Figure 6. Range in meters vs. Bit Error Rate per packet. Note most points are on the horizontal axis (0 bit errors per packet), and the total range at 110,000m represents ~150 nm.**



**Figure 7. Signal strength vs. range in meters.**



## flight xdr130628\_030058.txt

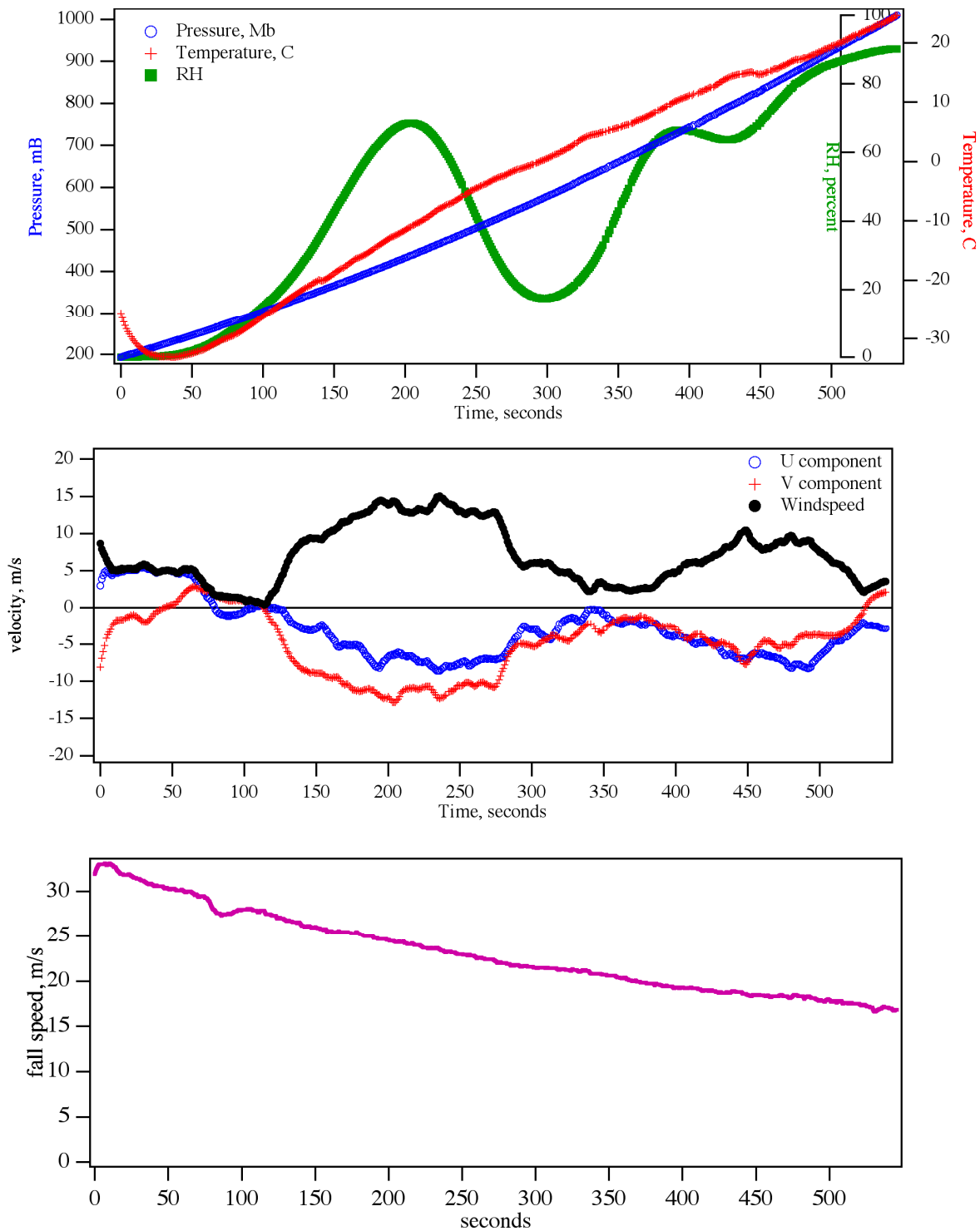


Figure 8. Example of XDD from DC-8.

The DC-8 telemetry test represented a significant milestone as it demonstrated that range demanded by high altitude, high speed jet aircraft such as the NASA WB-57 and Global Hawk can be satisfied. Notably, the telemetry range exceeds that of the AVAPS on AV-6, which has experienced electromagnetic interference from Ku satcom last fall. (Admittedly, the DC-8 only has 1.620 GHz Iridium satcom not 300 Watt Ku satcom the GH has. This is why we'll test Ku on the WB-57 in September 2013.)

## IMPACT/APPLICATIONS

Once demonstrated to be safe and reliable the HDSS will positively impact the government's ability to routinely profile tropical cyclones with unprecedented spatial resolution. It will also enable us to proceed onto Global Hawk integration in support of the HS-3 mission (which ONR partially funds) and future tropical cyclone missions such as Outflow.

## TRANSITIONS

We anticipate further engineering for Test and Integration of the HDSS with NASA AV-1 Global Hawk (GH) by designing a new exit cowl, pneumatic system and mechanical frame mount. During this period a second HDSS could be built to support simultaneous WB-57 and GH HDSS deployments.

## RELATED PROJECTS

The original R&D work for the Automated Dropsonde Dispenser, the core of the High Definition Sounding System was conducted via an ONR-funded *Small Business Innovation and Research program* Phase I/II completed in June 2011 with a successful test flight on the Navy Postgraduate School's Twin Otter aircraft off the coast of San Francisco.

## PUBLICATIONS

On July 10, NASA published a press release for our June DC-8 long range telemetry test:

<http://www.nasa.gov/content/nasas-dc-8-flight-helps-validate-new-technologies/#.Ug96J1JYWS0>

### ***NASA's DC-8 Flight Helps Validate New Technologies July 10, 2013***

NASA's DC-8 airborne laboratory has flown Earth science missions for more than 25 years. The converted jetliner recently carried several instruments testing new technologies that could aid those missions, Global Positioning System accuracy and aviation safety in years to come.



**Figure 9. Mark Beaubien, (left) of Yankee Environmental Systems, and Lee Harrison, of the State University of New York at Albany, prepare to dispense a soda-can sized dropsonde from NASA's DC-8 flying laboratory shown at right. The drop tube is just located forward of the rearmost DC-8 door.**

One such instrument is the High Definition Sounding System comprised of dropsondes using long-range telemetry. The instrument was developed by Yankee Environmental Systems in western Massachusetts and funded by the Navy, NOAA and a Phase 1 Small Business Innovation Research (SBIR) grant through NASA's Ames Research Center at Moffett Field, Calif. Eight soda-can sized sondes were dispensed during flight, sending back data on pressure, temperature, humidity, winds and sea surface temperature.

Next phase of the dropsonde study will be flown in September on several NASA WB-57 flights when up to 96 sondes per flight will be automatically dispensed at high altitude. This research, which includes flights on NASA's P-3B flying laboratory, is leading up to installation on a NASA Global Hawk for the 2014 Hurricane and Severe Storm Sentinel mission.

(Image Credit / author Beth Hagenauer, Public Affairs / NASA Dryden Flight Research Center.)

## NASA Atmospheric Science Program WB-57 Flight Request

We submitted the following WB-57 SOFRS flight request to NASA; requests were made for the P-3/DC-8. We submitted a Payload Design Package and will fly in September 2013.

Flight Request: HDSS WB-57 integration and flight test		Open	
Submitted: 18 Jun, 2013			
<b>General Info</b>			
Project Title:	HDSS WB-57 integration and flight test	Status:	Open
Request Type:	Normal	Log Number:	
NA SA Funded:	Yes	Fiscal Year:	2013
ROSES Call:	No	Contract Grant #	
Flight Hours Requested (if known):	10	(if applicable):	
Rationale for use of NA SA Facilities:			
Increase TRL of HDSS in preparation for Global Hawk deployments in 2014 onward with anticipated TRL-6 after successful flight. NASA WB-57 is unique in ability to simulate the environment identical to GH. Flight will also test the continuous reception of telemetry via three reception antennas, one on each wingtip plus a third on fuselage, to eliminate interruption of sounding data during maneuvers.			
<i>For Aircraft Use Only</i>			
Flight Hours		Cost Estimate	
For Approval:		Due Date:	
Approved:		Flight Hours:	
Flown:		MPC:	
		Integration:	
		Other:	
		Current Total:	
		Comments:	
Piggyback Request:		No	
		FR ID: 20130618-133211	
No related requests			
<b>PI &amp; Funding</b>			
Principal Investigator			
Mark Beaubien - Yankee Environmental Systems			
Funding Source			
Bruce Tagg - NASA - SMD - ESD Airborne Science Program			
NASA HQ Science Concurrence			
Hal Maring - NASA - SMD - ESD Radiation Science Program			
Associated Users			
Mark Beaubien - Yankee Environmental Systems			
<b>Science Objectives and Mission Concept-of-Operation</b>			
Science Objectives:			
The HDSS will ultimately fly on the Global Hawk. This WB-57 test is a dry run primarily to test HDSS operation in a high altitude (~25,000') low pressure, low temperature environment identical to Zone 61 of Global Hawk. We also will verify noise performance and descent rate. Navy is providing 200 XDD dropsondes and we plan to share sounding data with SEACRAS and/or HS-3. In that context we would like to drop a few through convection of opportunity. Pete Black to design the detailed surveillance flight plan based on weather situation.			
Mission Concept-of-Operation:			
Flight plan: a. Take off NASA JS C climb to near maximum cruise altitude over the Gulf. b. Drop multiple XDD devices to test rapid fire and separation, fall rates etc. c. make aircraft turns to verify telemetry reception from multiple antennas. d. fly over an active precipitation event in the area and dispense more XDD dropsondes e. collect data while flying straight and level (~25 to 30 minutes) while they all descend. Idea is to create a worst case "high speed, high altitude, plane is flying away over the RF horizon" situation to stress the RF link and test link performance in/on water			
<b>Supported Satellites</b>			
None provided			
<b>Additional Contact</b>			
This field provides the aircraft lead's with an additional contact who is not already listed in this FR. (This field has been modified from "advanced notification" to "additional contact").			
None provided			